PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 04 October 2000 (04.10.00)	
International application No. PCT/ZA00/00031	**Applicant's or agent's file reference** PCT/2000/033
International filing date (day/month/year) 24 February 2000 (24.02.00)	**Priority date** (day/month/year) 24 February 1999 (24.02.99)
Applicant VISSER, Barend	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

06 September 2000 (06.09.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Antonia Muller
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

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PATENT COOPERATION TREATY

PCT

REC'D 15 JUN 2001
WIPO PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
PCT/2000/033		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/ZA00/00031	24/02/2000	24/02/1999
International Patent Classification (IPC) or national classification and IPC C01B13/11		
Applicant POTCHEFSTROOM UNIVERSITY FOR CHRISTIAN ... et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
06/09/2000	13.06.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Krafka, B Telephone No. +49 89 2399 8140

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/ZA00/00031

I. Basis f th rep rt

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-10 as originally filed

Claims, No.:

1-19 as originally filed

Drawings, sheets:

1/9-9/9 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	4,8
	No:	Claims	1-3,5-7,9-19
Inventive step (IS)	Yes:	Claims	
	No:	Claims	4,8
Industrial applicability (IA)	Yes:	Claims	1-19
	No:	Claims	

2. Citations and explanations
   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

R It m V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive st p or industrial applicability; citations and explanations supporting such statem nt

1) Reference is made to the following documents:

D1: US-A-4 038 165
D2: US-A-4 869 881
D3: DE 196 33 368

2) Novelty - Art. 33 (1) and (2) PCT

2.1. D1 discloses a method for producing ozone by conversion of oxygen in the presence of an electrical corona discharge (c. 1 l. 10-13 and 64-68) produced by narrow high voltage pulses (c. 2 l. 35-41). A DC power supply is used. The peak voltage is 2-200 kV, the pulse width is 0.1-200 kHz (claim 2) and the field is 0.05-3 kV/mm (c.12 l. 59-63). Therefore, in the light of D1 the subject-matter of claims 1, 2, 3, 5 and 17 is not regarded as novel.

2.2. D1 further discloses an apparatus for carrying out the method for producing ozone (figures 1 and 2). It comprises a housing for passing the oxygen-containing fluid by an electrode which is disposed adjacent of the passage of the fluid, a DC power supply and a pulse generator. The field is 0.05-3 kV/mm (c.12 l. 59-63). The charge storage means comprises a capacitor. The electrode is connected to the second winding of the transformer, whereas the first winding is connected to the power supply. Therefore, in the light of D1 the subject-matter of claims 6-7 and 13 is not regarded as novel.

2.3. D2 discloses an ozone generator system employing the corona discharge principle (c. 1 l. 19-28). Constant voltage pulses at intermittent intervals are provided (c. 3 l. 17-23). Therefore, in the light of D2 the subject-matter of claims 1 and 5 is not regarded as novel.

2.4. D2 further discloses the apparatus used for producing ozone (c. 5 l. 37 - c. 6 l. 56) comprising a housing, an electrically conductive tubular electrode disposed in the

housing (figures 2-8), a passage for air and a pulse generator. The conductive housing is connected to the secondary winding of a transformer (figures 7-8). In another embodiment the housing is electrically insulating (figures 9-12). The apparatus further comprises a timing unit including a MOSFET and capacitors (c. 7 l. 6-61). Therefore, in the light of D2 the subject-matter of claims 6, 9-16 is not regarded as novel.

2.5. Claims 18 and 19 are not defined on the basis of technical features, but only by reference to the accompanying drawings (which is not acceptable; see VIII.a). Accordingly, claims 18 and 19 are not regarded as establishing novel subject-matter.

3) Inventive Step - Art. 33 (1) and (3) PCT

3.1. The technical problem underlying the present invention can be seen in providing an improved method and apparatus for producing ozone, avoiding the disadvantage of the prior, energy loss in form of heat and low yield ratio of ozone. This problem is overcome by the present invention by generating intermittent bursts of corona discharge in an electrode region trough which oxygen-containing fluid is passed. Thereby the oxygen is ionized.
Documents D1 and D2 are considered to represent the closest prior art.

3.2. D3, which is very close to both D1 and D2, also discloses a method and apparatus for producing ozone via corona discharge. In D3 short high voltage pulses (200 ns) are used (p. 2 l. 39); all other features are basically identical to the ones claimed in claims 1-5 except of the peak value of the field, which is 0.2 - 1 kV/mm in D3 (p. 3 l. 30). It is regarded as obvious to a person skilled in the art to combine the teachings of D3 with either D1 or D2. The use of short voltage pulses, as is subject-matter of claims 4 and 8, is therefore not regarded as inventive.

Re Item VII

Certain defects in the international application

a. Documents reflecting the prior art are missing from the description (Rule 5.1(a)(ii) PCT).

b. The term "spirit of the invention" casts a doubt upon the extent to which the description supports the claims (Art. 6 PCT).

Re Item VIII

Certain observations on the international application

a. Claims 18 and 19 contain references to the drawings. According to Rule 6.2(a) PCT, claims should not contain such references except where absolutely necessary, which is not the case here.

b. The term "oxygen-containing fluid" as used e.g. in claim 1 is vague. It also encompasses substances in which the oxygen is chemically bound, like e.g. water or an organic acid such as acetic acid. It is assumed that the fluid should contain oxygen in the form of O_2.

ENT COOPERATION TREATY

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
PCT/2000/033		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/ZA 00/ 00031	24/02/2000	24/02/1999
Applicant		
POTCHEFSTROOM UNIVERSITY FOR CHRISTIAN HIGHER EDUC		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 7

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

[redacted] International Application No
[redacted] ZA 00/00031

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C01B13/11

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE WPI Section Ch, Week 198320 Derwent Publications Ltd., London, GB; Class D15, AN 1983-48813K XP002138944 & SU 941 276 B (KIEV ENG CONS INST), 17 July 1982 (1982-07-17) abstract	1-3
X	US 3 883 413 A (DOUGLAS-HAMILTON DIARMAID H) 13 May 1975 (1975-05-13) column 3, line 59 -column 4, line 8	1
X	US 4 038 165 A (LOWTHER FRANK EUGENE) 26 July 1977 (1977-07-26) claim 1; figure 1	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 June 2000	20/06/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Clement, J-P

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EA 00/00031

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 869 881 A (COLLINS WAYNE M) 26 September 1989 (1989-09-26) column 7, line 43 - line 61	1
X	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 10, 31 October 1997 (1997-10-31) & JP 09 156904 A (MEIDENSHA CORP), 17 June 1997 (1997-06-17) abstract	1
X	DE 196 33 368 A (KOESTER VOLKWIN ;DANILOV VLADIMIR (DE); CESTAKOV VIACESLAV (RU)) 26 February 1998 (1998-02-26) claim 1	1
X	US 4 713 220 A (HUYNH ANH N ET AL) 15 December 1987 (1987-12-15) column 1, line 28 -column 3, line 28; figure 2	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/ZA 00/00031

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
SU 941276	B	07-07-1982	NONE		
US 3883413	A	13-05-1975	CA	1005014 A	08-02-1977
			CH	584058 A	31-01-1977
			DE	2348257 A	04-04-1974
			FR	2200054 A	19-04-1974
			GB	1441931 A	07-07-1976
			IL	43303 A	31-05-1976
			IT	994768 B	20-10-1975
			JP	49087590 A	21-08-1974
			SE	396360 B	19-09-1977
US 4038165	A	26-07-1977	US	4016060 A	05-04-1977
			AU	504023 B	27-09-1979
			AU	1308776 A	20-10-1977
			BR	7602285 A	10-05-1977
			CA	1066659 A	20-11-1979
			CH	612595 A	15-08-1979
			DE	2617104 A	26-05-1977
			FR	2338074 A	12-08-1977
			GB	1551951 A	05-09-1979
			IT	1058158 B	10-04-1982
			NL	7604086 A	20-05-1977
			NO	761302 A	20-05-1977
			SE	432092 B	19-03-1984
			SE	7604399 A	18-05-1977
			AU	503689 B	13-09-1979
			AU	1201076 A	22-09-1977
			CA	1067854 A	11-12-1979
			DE	2610809 A	23-09-1976
			FR	2303588 A	08-10-1976
			GB	1549272 A	01-08-1979
			GB	1549273 A	01-08-1979
			IT	1062447 B	10-10-1984
			JP	1395180 C	11-08-1987
			JP	51139575 A	01-12-1976
			JP	62000841 B	09-01-1987
			NL	7602690 A	15-09-1976
			NO	760892 A,B,	14-09-1976
			SE	428679 B	18-07-1983
			SE	7603275 A	14-09-1976
			US	RE30320 E	01-07-1980
US 4869881	A	26-09-1989	NONE		
JP 09156904	A	17-06-1997	NONE		
DE 19633368	A	26-02-1998	NONE		
US 4713220	A	15-12-1987	US	4680694 A	14-07-1987
			CA	1276225 A	13-11-1990
			CH	670537 A	15-06-1989
			DE	3613411 A	23-10-1986
			FR	2580875 A	24-10-1986
			JP	8024425 B	06-03-1996
			JP	61251487 A	08-11-1986

METHOD AND APPARATUS FOR PRODUCING OZONE

TECHNICAL FIELD

This invention relates to a method and apparatus for producing ozone.

BACKGROUND ART

A known method for producing ozone includes the steps of passing oxygen at 1 atmosphere and 25°C through concentric metallised glass tubes to which low-frequency power at 50-500 Hz and 10-20 kV is applied. Due to the relatively slow change in potential (5kV per millisecond), a corona or silent electric discharge is maintained between the electrodes. A disadvantage of this method is that energy is lost in the form of heat, and a relatively low yield ratio of ozone is achieved.

OBJECTIVE OF THE INVENTION

It is accordingly an object of the present invention to provide a method and apparatus for producing ozone with which the aforesaid disadvantage may be overcome or to provide a useful alternative to the known method.

SUMMARY OF THE INVENTION

According to the invention there is provided a method of producing ozone comprising the steps of generating intermittent bursts of corona discharge in an electrode region, and passing oxygen-containing fluid through the region,

thereby to cause ionization of the oxygen.

The intermittent bursts may be generated by generating a changing electric field in the region by energising the electrode with intermittent voltage pulses having a slope of at least 2kV/100ns, the field having a peak value of at least 2kV per millimetre. In this specification, the word "slope" is used to denote the slope between 30% and 70% of the peak to peak value of the pulse.

Preferably, the peak value is at least 3kV per millimetre and the slope is in the order of 3kV/10ns.

Each voltage pulse preferably has a pulse width of less than 100ns.

The bursts may be discrete bursts.

The invention also includes within its scope apparatus for producing ozone comprising:

- a housing defining a passage for a fluid comprising oxygen;
- an electrode disposed adjacent the passage; and
- pulse generating means connected to the electrode,
- the pulse generating means being operative to generate a changing electric field by generating a train of voltage pulses

each having a slope of at least 20kV/100ns.

The electric field has a peak value of at least 3kV per millimetre.

Each voltage pulse preferably has a pulse width of less than 100ns.

The pulse generating means may comprise a self-oscillating circuit.

The self-oscillating circuit may comprise a field effect transistor (FET) and a switch circuit therefor, the switch circuit comprising charge storage means; switching means connected between the charge storage means and a gate of the FET; the switching means being operative to deposit charge from the storage means onto the gate, thereby to improve a rise time of a signal in a drain-source circuit of the FET.

The charge storage means may comprise a capacitor and the switch means may comprise a SIDAC.

The electrode may be connected to a secondary winding of a transformer, a primary winding of the transformer being connected in the drain-source circuit of the FET.

The passage may extend between an inlet to the housing and an outlet

therefrom.

The electrode may be an annular electrode disposed in the housing and the passage may extend through a clearance defined between the electrode and an annular ridge in the housing.

The housing may be a metal housing, the housing may be connected to the secondary winding of the transformer and an insulating carrier for the electrode may be mounted on shoulder formations in the housing.

In another embodiment the housing may be of an electricity insulating material, the electrode may be disposed circumferentially on the outside of the housing and a second electrode also connected to the secondary winding may be provided spaced from an inner wall of the housing, to define the passage between the second electrode and the inner wall.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described further, by way of example only, with reference to the accompanying drawings wherein:

figure 1 is an exploded perspective view of apparatus according to a first embodiment of the invention for producing ozone;

figure 2 is an exploded perspective view of a closure and electrode

assembly of the apparatus of figure 1;

figure 3 is a perspective view of the closure and electrode assembly of figure 2 when assembled;

figure 4 is a schematic representation of an electronic circuit used to generate a train of voltage pulses that is applied to the electrode assembly of figures 2 and 3.

figures 5(a);(b);(c); and (d) are voltage waveforms against a first time scale at points a, b, c, and d in figure 4;

figures 6(a);(b);(c); and (d) are the same wave forms against a larger time scale;

figure 7 is a cross-sectional view on line VII in figure 3;

figure 8 is a partially broken away perspective view of apparatus according to a second embodiment of the invention for producing ozone; and

figure 9 is a cross-sectional side view of a central portion of the apparatus of figure 8.

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring to figure 1, apparatus according to a first embodiment of the invention for producing ozone, is generally designated by reference numeral 10.

The apparatus 10 includes a tubular anodised aluminium housing 12 having an open end 14 and a closed end 16, and a separate closure 18 for closing the

open end. The apparatus 10 further includes an electrode assembly 20 mountable on the closure 18 and pulse generating means in the form of an electronic circuit 30 (shown in figure 4) for energising the electrode assembly 20.

An inlet 22 to the housing is provided in the closed end 16 and an outlet 24 is defined in the closure 18. A passage 21 (shown in figure 7) extends from the inlet 22 to the outlet 24.

As best shown in figures 1 and 7, the electrode assembly 20 comprises an insulating disc or base 20.1 of an ozone and corona resistant material, such as glass, alumina etc and an annular electrode 20.2 mounted on the face of the base 20.1 facing away from the closure 18. The base 20.1 is provided with a plurality of spaced peripheral notches 20.3, the purpose of which will be described hereinafter.

The closure 18 is provided with an annular ridge formation 18.1. As best shown in figure 7, when the electrode assembly 20 is mounted on shoulder formations on the closure 18, the ridge formation 18.1 is disposed in close proximity, but with a clearance 23 of approximately 0.3mm from the base 20.1.

The aforementioned passage 21 extends from the inlet 22 along the tubular

housing 12, through the notches 20.3 in the base, through the clearance 23 between the ridge formation 18.1 and the base 20.1, and out via the outlet 24.

As will be described hereinafter, a rapidly changing electric field is established in the passage 21 in the region of the ridge formation 18.1 causing a corona discharge and oxygen flowing along the passage 21 in use, therefore passes through the field. The effect of the electric field is that instantaneous ionisation of oxygen is achieved by the corona discharge to produce ozone from the oxygen, without substantial energy loss in the form of heat generated.

The applicant has found that the ozone yield ratio is dependant on the rise time t_r, the fall time t_f and width w_p of the pulses 50 (shown in figure 5(d)) in the train 52 of pulses (shown in figure 6(d)) applied to the electrode assembly 20. It is believed that the shorter the rise and fall times and/or the pulse width, the more efficient the apparatus becomes.

A self-oscillating circuit 30 for energizing the electrode assembly 20 is shown in figure 4. Voltage waveforms as measured at points a, b, c and d are shown in figures 5(a), (b), (c) and (d) respectively and also in figures 6(a), (b), (c) and (d) respectively.

The circuit 30 comprises a capacitor 34 in parallel with a SIDAC 36 and inductor

37. The SIDAC is connected to the gate 39 of a field effect transistor (FET) such as a MOSFET 38 of the type IRF 740, for example. The SIDAC 36 conducts current when a voltage exceeding a certain threshold (100V for example) is applied across it. A primary winding of a transformer 43 is connected in the drain-source circuit 45 of the MOSFET 38. The secondary winding of the transformer is connected to the electrode assembly 20 as shown in figure 4.

A DC voltage of about 150V is applied at point 41 of the circuit. Initially the potential difference across the SIDAC 36 is insufficient to cause the SIDAC 36 to switch on and hence the capacitor 34 is charged up. When the voltage over the SIDAC 36 exceeds the aforementioned threshold voltage of the SIDAC 36, it switches on, resulting in a closed circuit from the capacitor 34 to the gate 39 of the MOSFET 38, partially discharging the capacitor 34 and hence charging the gate 39. The result is that a charge will now be shared between the capacitor 34 and the gate 39, so that some voltage, preferably sufficiently above the gate threshold voltage (typically 6V) relative to ground, is applied to the gate. The current that discharges from the capacitor 34 through to SIDAC 36 is applied to the gate 39 of the MOSFET 38 slightly prior to the onset of current flow in the drain-source circuit 45. As a result of the current from the capacitor, the voltage on the gate exceeds the aforementioned threshold voltage by a sufficient amount. The resulting signals at points a, b, c and d are shown in

figures 5(a) to (d) respectively and in figures 6(a) to (d), respectively.

Using this method, the gate voltage may for short intervals be driven approximately two to four times beyond the maximum threshold voltage rating of some MOSFET's without destroying the device.

As will be seen from figures 5(d) and 6(d) each of the pulses 50 in the train 52 of voltage pulses applied to the electrode assembly has a 30% - 70% slope or rise time t_r and a fall time t_f of better than 2kV/100ns, preferably in the order of 3kV/10ns. Furthermore, the width of the pulses w_p as they pass through the average value 54 is shorter than 100ns, preferably shorter than 30ns.

The peak value of the voltage applied to the electrode assembly is in the order of 3kV and with the clearance between the electrode 20.2 and the ridge 18 .1 in the order of 0.3mm, the maximum electric field strength $\bar{E}$ is bigger than 3kV/mm, preferably in the order of 10kV/mm.

Referring to figures 7 and 8, apparatus according to a second embodiment of the invention for producing ozone, is generally designated by reference numeral 100.

The basic working of the apparatus 100 is similar to that of apparatus 10, but

the construction of apparatus 100 differs in that the housing 102 is manufactured from an insulating material. The apparatus 100 includes a first electrode 104, which comprises a conductive annulus extending around the housing 102 and a second electrode 106 disposed inside the housing 102.

The second electrode 106 is provided with an annular ridge formation 106.1 disposed in close proximity to the inner wall of the housing 102, in the region of the first electrode 104. The first electrode 104 is connected to the self-oscillating circuit and the second electrode 106 is earthed. A corona discharge is therefore established between the ridge formation 106.1 and the inner wall of the housing 102, causing the production of ozone as hereinbefore described.

It will be appreciated that there are many variations in detail on the method and apparatus according to the invention without departing from the scope and spirit of the appended claims.

CLAIMS

1. A method of producing ozone comprising the steps of generating intermittent bursts of corona discharge in an electrode region, and passing oxygen-containing fluid through the region, thereby to cause ionization of the oxygen.

2. A method as claimed in claim 1 wherein the intermittent bursts are generated by generating a changing electric field in the region by energising the electrode with intermittent voltage pulses having a slope of at least 2kV/100ns, the field having a peak value of at least 2kV per millimetre.

3. A method as claimed in claim 2 wherein the peak value is at least 3kV per millimetre and the slope is in the order of 3kV/10ns.

4. A method as claimed in claim 2 or claim 3 wherein each voltage pulse has a pulse width of less than 100ns.

5. A method as claimed in any one of the preceding claims wherein the bursts are discrete bursts.

6. Apparatus for producing ozone comprising:

- a housing defining a passage for a fluid comprising oxygen;
- an electrode disposed adjacent the passage; and
- pulse generating means connected to the electrode,
- the pulse generating means being operative to generate a changing electric field by generating a train of voltage pulses each having a slope of at least 20kV/100ns.

7. Apparatus as claimed in claim 6 wherein the electric field has a peak value of at least 3kV per millimetre.

8. Apparatus as claimed in claim 6 or claim 7 wherein each voltage pulse has a pulse width of less than 100ns.

9. Apparatus as claimed in any one of the preceding claims wherein the pulse generating means comprises a self-oscillating circuit.

10. Apparatus as claimed in claim 9 wherein the self-oscillating circuit comprises a field effect transistor (FET) and a switch circuit therefor, the switch circuit comprising charge storage means; switching means connected between the charge storage means and a gate of the FET; the switching means being operative to deposit charge from the storage means onto the gate, thereby to improve a rise time of a signal in a

drain-source circuit of the FET.

11. Apparatus as claimed in claim 10 wherein the charge storage means comprises a capacitor and the switch means comprises a SIDAC.

12. Apparatus as claimed in claim 10 or claim 11 wherein the electrode is connected to a secondary winding of a transformer, a primary winding of the transformer being connected in the drain-source circuit of the FET.

13. Apparatus as claimed in any one of claims 6 to 12 wherein the passage extends between an inlet to the housing an outlet therefrom.

14. Apparatus as claimed in any one of claims 6 to 13 wherein the electrode is an annular electrode disposed in the housing and wherein the passage extends through a clearance defined between the electrode and an annular ridge in the housing.

15. Apparatus as claimed in claim 14 wherein the housing is a metal housing, wherein the housing is also connected to the secondary winding of the transformer and wherein an insulating carrier for the electrode is disposed between the electrode and the ridge.

16. An apparatus as claimed in claim 14 wherein the housing is of an electricity insulating material, wherein the electrode is disposed circumferentially on the outside of the housing and wherein a second electrode also connected to the secondary winding is provided spaced from an inner wall of the housing, to define the passage between the second electrode and the inner wall.

17. A method of producing ozone, the method comprising the steps of:

- generating a changing electric field in an electrode region; the field having a peak value of at least 2kV per millimetre;
- generating the electric field by energizing the electrode with intermittent voltage pulses having a slope of at least 2kV/100ns; and
- passing oxygen-containing fluid through the region.

18. A method of producing ozone substantially as herein described with reference to the accompanying diagrams.

19. Apparatus for producing ozone substantially as herein described with reference to the accompanying diagrams.

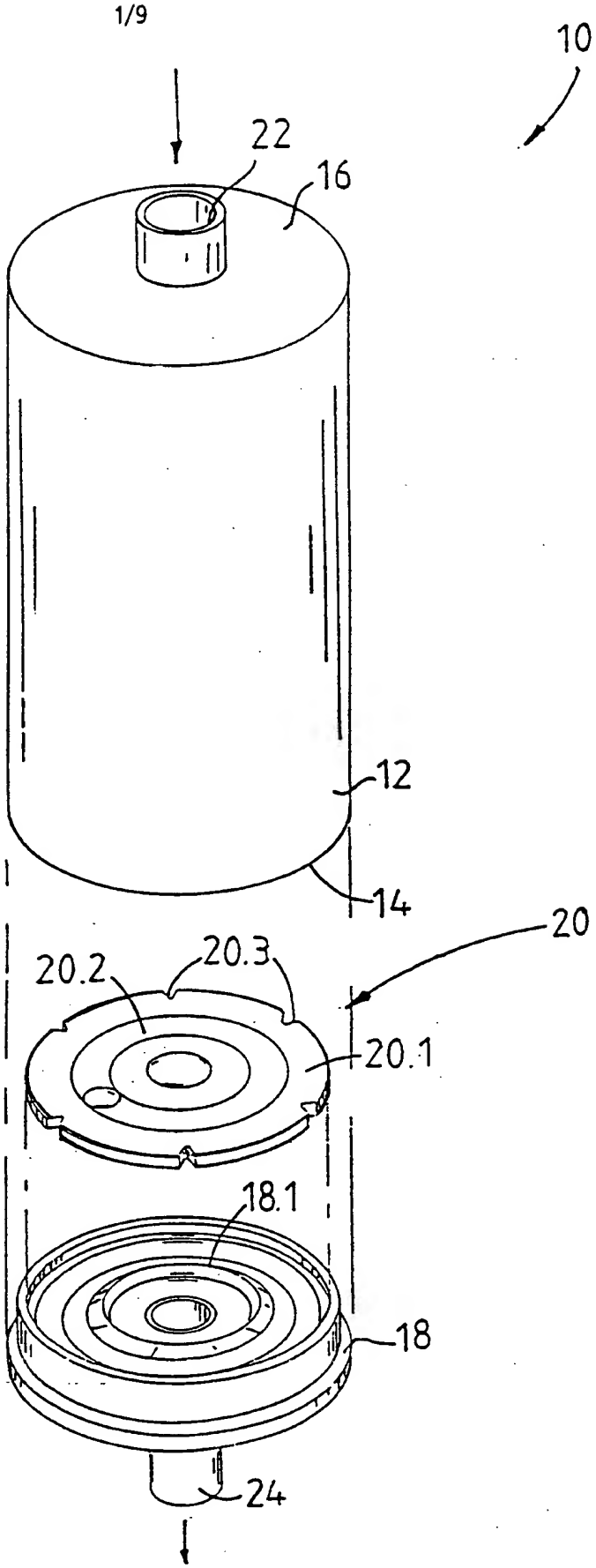

FIGURE 1

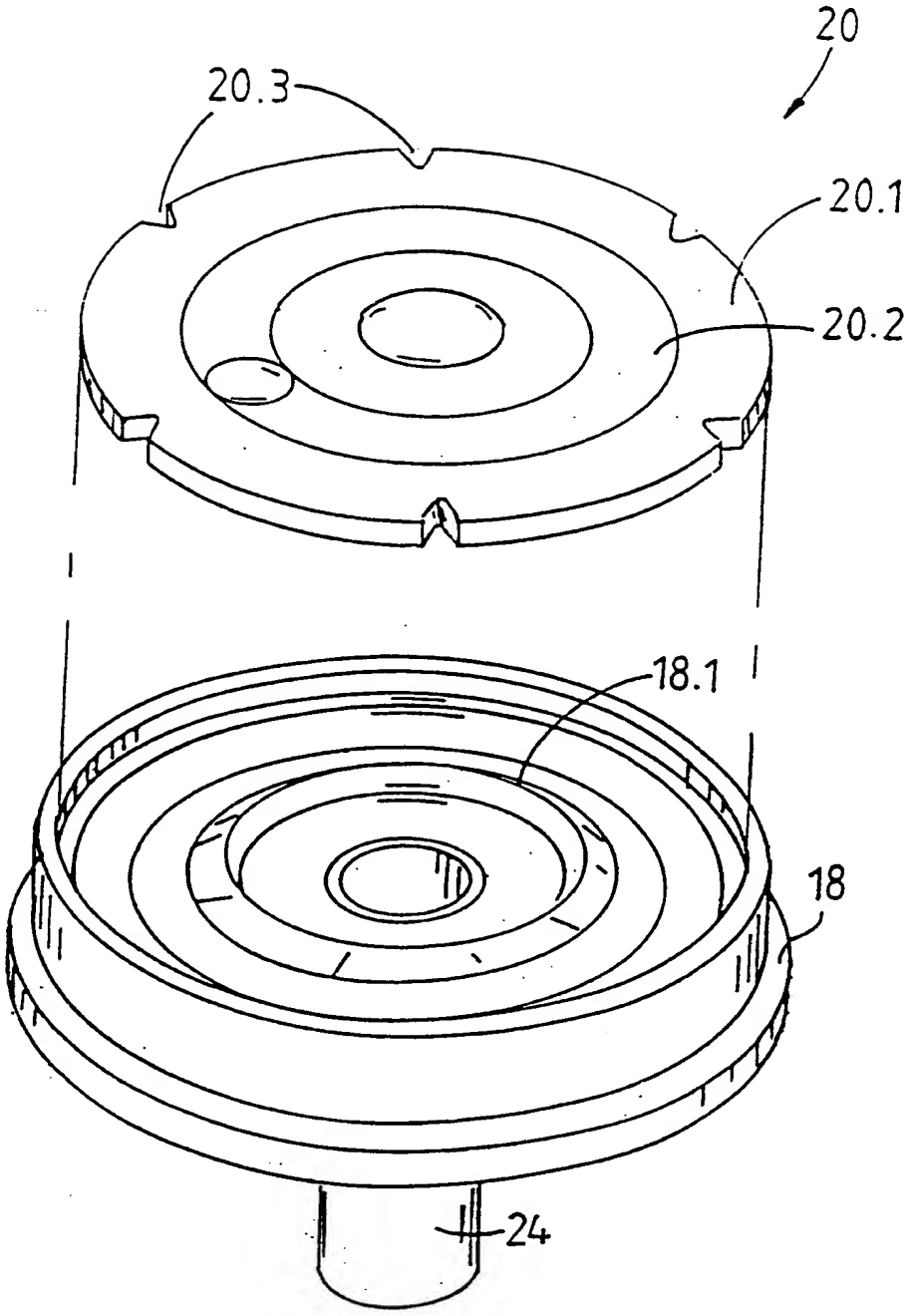

FIGURE 2

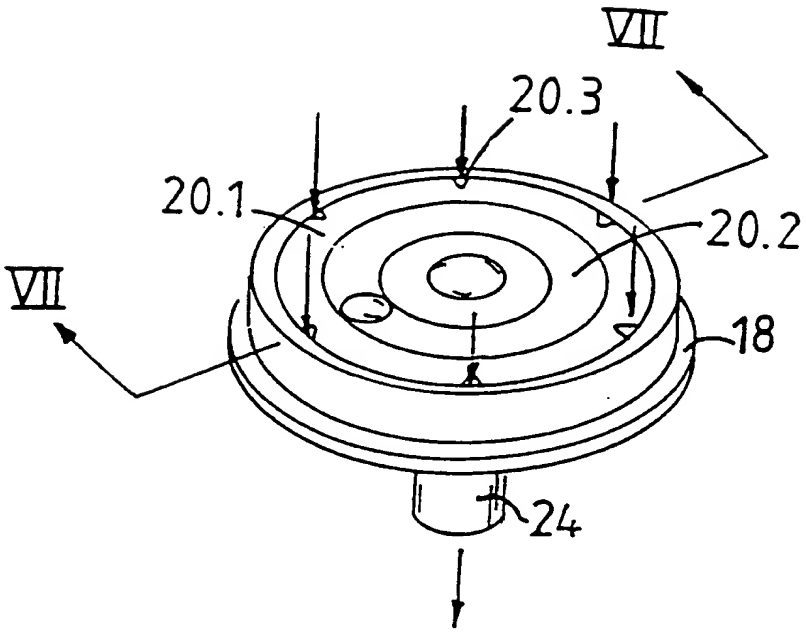

FIGURE 3

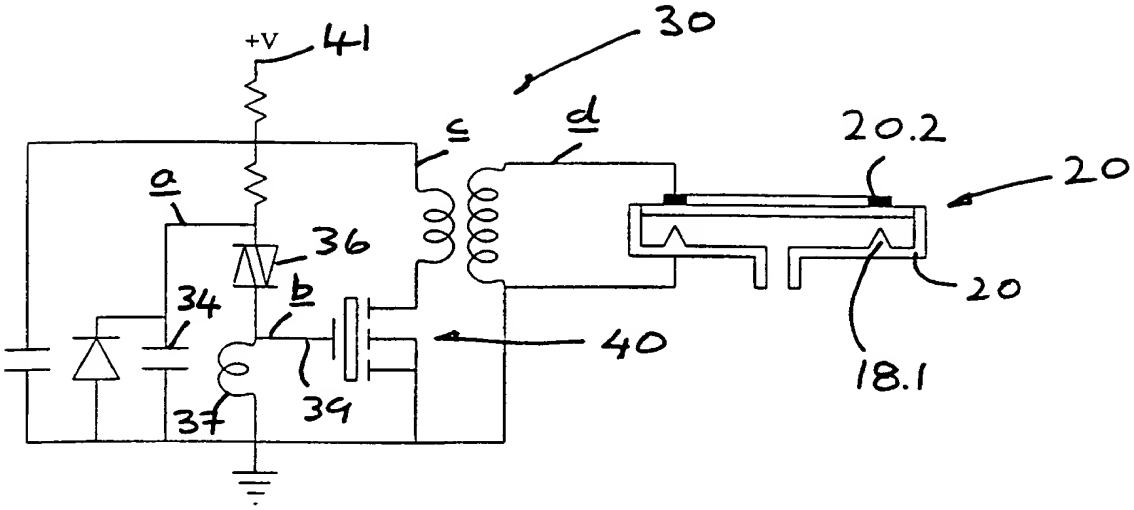

FIGURE 4

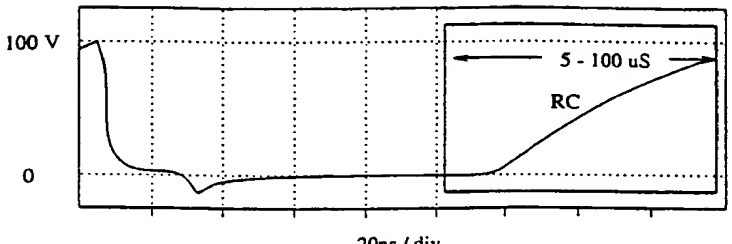

FIGURE 5(a)

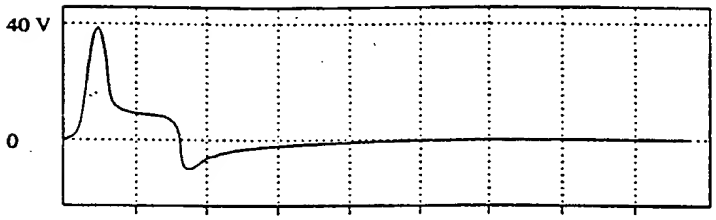

FIGURE 5(b)

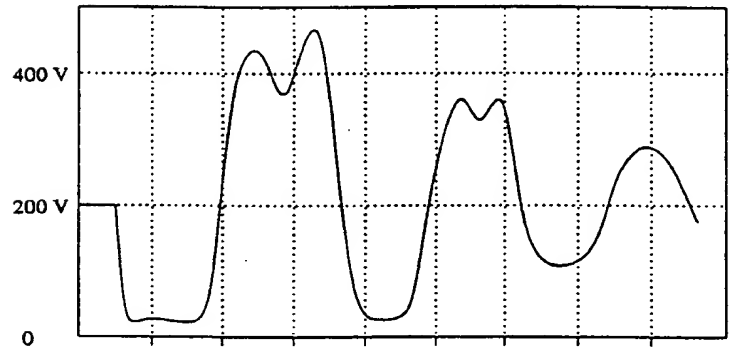

FIGURE 5(c)

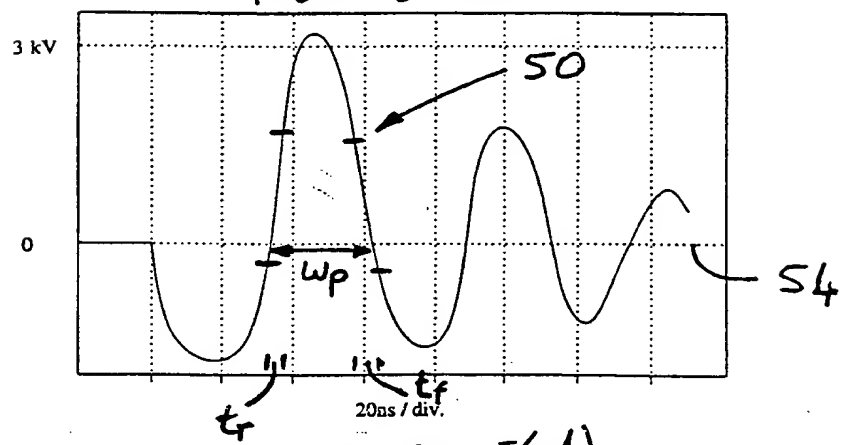

FIGURE 5(d)

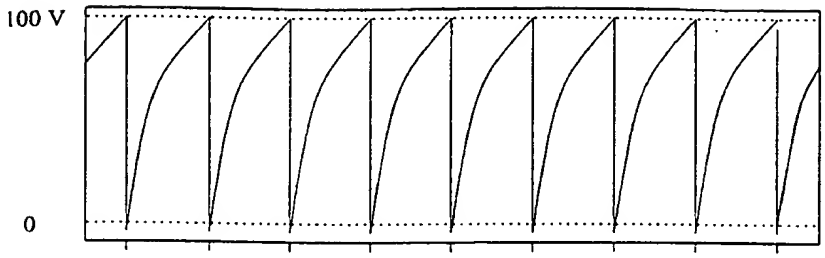

FIGURE 6(a)

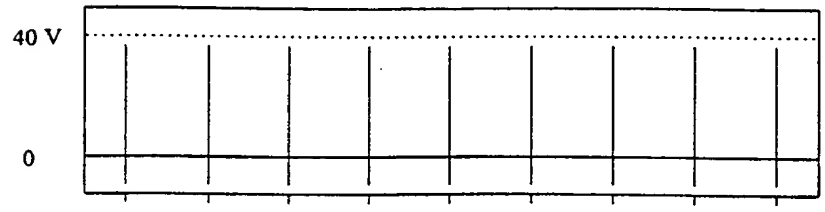

FIGURE 6(b)

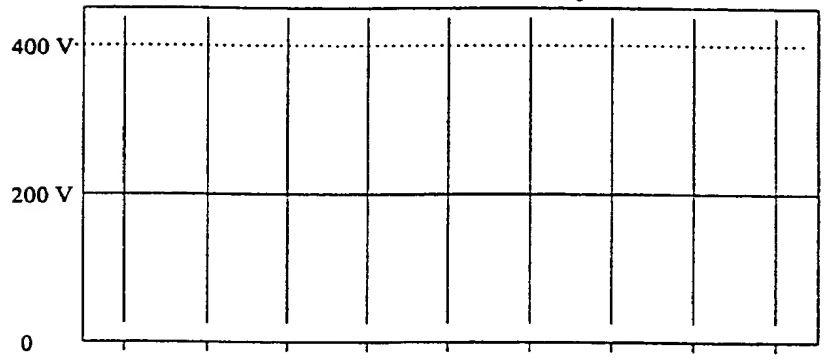

FIGURE 6(c)

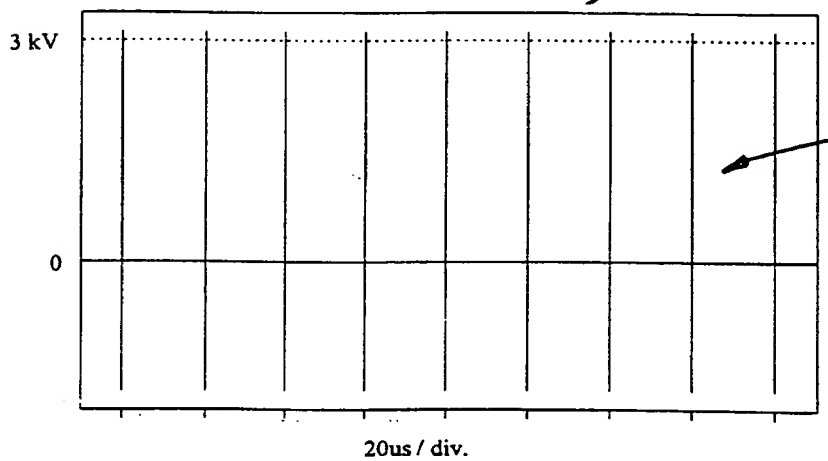

FIGURE 6(d)

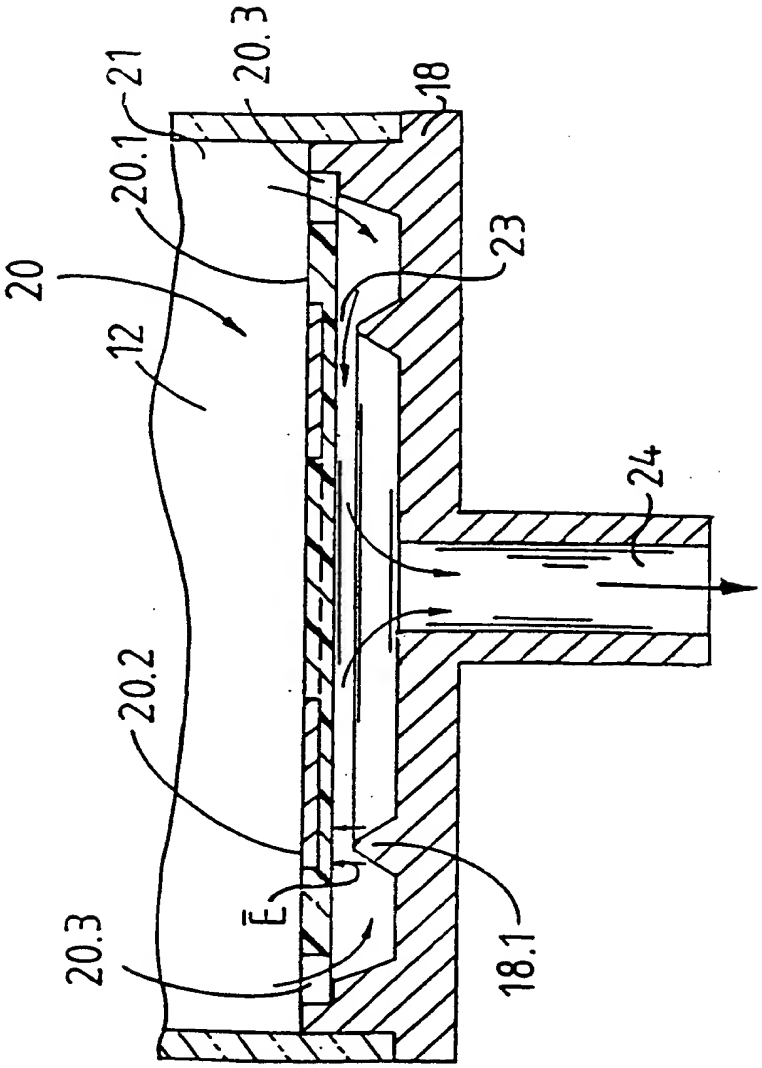

FIGURE 7

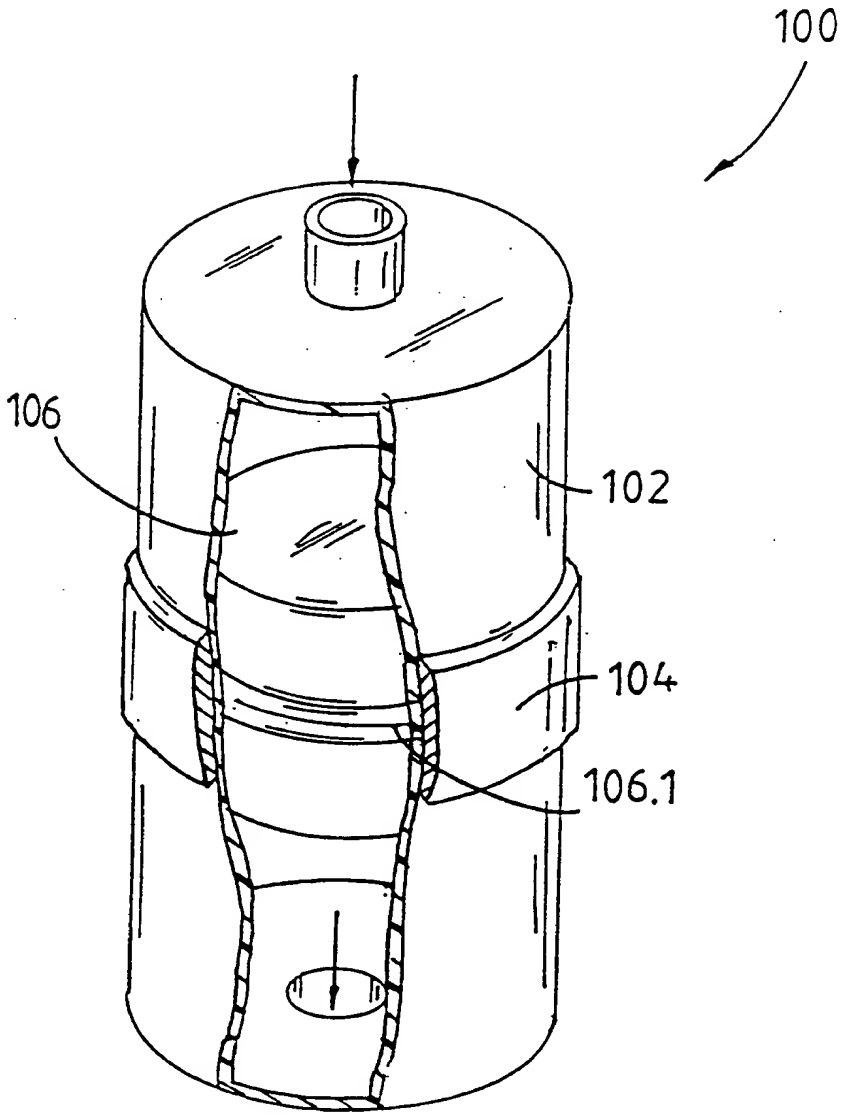

FIGURE 8

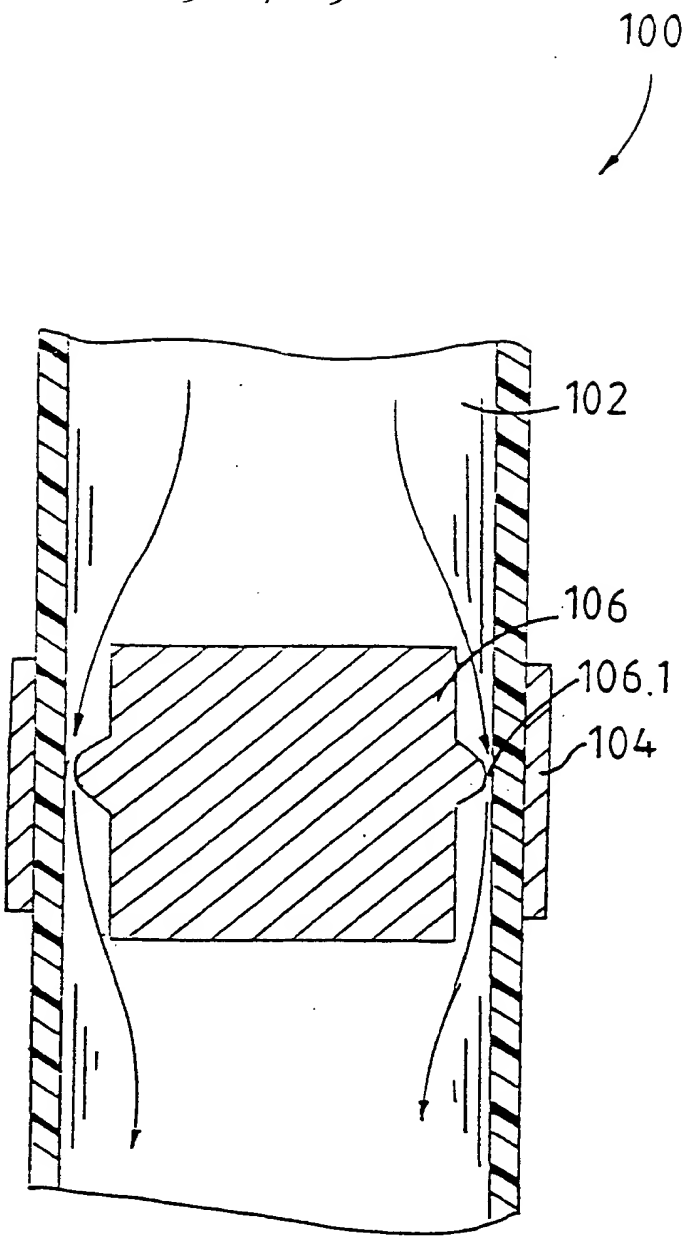

FIGURE 9

INTERNATIONAL SEARCH REPORT

International Application No
PCT/ZA 00/00031

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C01B13/11

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE WPI Section Ch, Week 198320 Derwent Publications Ltd., London, GB; Class D15, AN 1983-48813K XP002138944 & SU 941 276 B (KIEV ENG CONS INST), 17 July 1982 (1982-07-17) abstract ---	1-3
X	US 3 883 413 A (DOUGLAS-HAMILTON DIARMAID H) 13 May 1975 (1975-05-13) column 3, line 59 -column 4, line 8 ---	1
X	US 4 038 165 A (LOWTHER FRANK EUGENE) 26 July 1977 (1977-07-26) claim 1; figure 1 --- -/--	1

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 June 2000	20/06/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Clement, J-P

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INTERNATIONAL SEARCH REPORT

Inte. ...ional Application No
PCT/ZA 00/00031

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 869 881 A (COLLINS WAYNE M) 26 September 1989 (1989-09-26) column 7, line 43 - line 61	1
X	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 10, 31 October 1997 (1997-10-31) & JP 09 156904 A (MEIDENSHA CORP), 17 June 1997 (1997-06-17) abstract	1
X	DE 196 33 368 A (KOESTER VOLKWIN ;DANILOV VLADIMIR (DE); CESTAKOV VIACESLAV (RU)) 26 February 1998 (1998-02-26) claim 1	1
X	US 4 713 220 A (HUYNH ANH N ET AL) 15 December 1987 (1987-12-15) column 1, line 28 -column 3, line 28; figure 2	1

1

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Information on patent family members

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